PREDICTING LOSSES FROM THE SARATOGA SPITTLEBUG FOR RED PINE MANAGEMENT DECISIONS

Robert L. Heyd[1/] and Louis F. Wilson[2/]

INTRODUCTION

The risk-rating system presented is currently used by the Michigan Department of Natural Resources to evaluate all proposed red pine planting sites and plantations less than ten years old for Saratoga spittlebug (Aphrophora saratogensis) damage. We quantify potential losses with this system and then provide forest land managers with management strategies based on sound economics. This has increased the utility of the forest pest management program and boosted many persons' interest in and opinion of the program.

In addition, as a result of an intensive one-day Saratoga spittlebug workshop much interest and demand for this system has surfaced from the U.S. Forest Service, consulting foresters, and industrial foresters.

THE PROBLEM

The Saratoga spittlebug occurs wherever red pine grows in eastern North America. It injures plantation red pine between 2 and 15 feet tall. Young plantations have failed from its damage. Severely injured plantations may survive but produce low grade products.

More specifically, adult Saratoga spittlebug feeding causes tree deformities such as lower-bole limbiness, large knots, crook and sweep, and loss of wood volume from growth loss and/or tree mortality. Crooked pulp sticks increase loading and hauling costs. In addition, by the time crook and sweep are visible much growth loss has already occurred. Injury often occurs in pockets within a planting and pocket openings product limby perimeter trees. Increased limbiness may cull perimeter trees for use as utility poles and pilings both of which have limitations on the number and size of knots.

1/ Regional Forest Pest Specialist, Forest Management Division, Michigan Department of Natural Resources, Marquette, Michigan.

2/ Principal Insect Ecologist, North Central Forest Experiment Station, East Lansing, Michigan.

RECOGNIZING THE SARATOGA SPITTLEBUG AND ITS INJURY

The spittlebug overwinters in the egg stage. Eggs are laid under the outer scales of large buds in the upper branches of red pine in mid to late summer. Usually several eggs are laid in each bud, causing a noticeable irregularity on the outer surface of the bud scales.

Hatching is usually complete by mid-May, and the young nymphs drop or are blown to the ground. They then crawl to alternate host plants on the plantation floor such as sweet-fern and begin feeding. As they feed they form the characteristic spittlemass. They pass through five stages or instars and after 7-10 weeks when fully developed, they leave the spittlemass, climb to the upper parts of their host plants, and transform to adults.

The adults then fly to the pine hosts and feed on the needle-bearing twigs. Their feeding period is from late June to the end of September, but their peak activity occurs between mid-July and mid-August. The adults can be identified by the white arrow-shaped mark on the head and thorax.

The first easily recognized symptom of adult spittlebug injury on red pine is one or more reddish-brown (flagged) branches. One can tell this is caused by the Saratoga spittlebug by scraping away the bark and looking for tan or brown flecks on the surface of the wood and inner bark. These are puncture wounds or scars that develop at the location of adult feeding and restrict nutrient and water transport in the branches. Light scarring causes reduced branch vigor and growth loss. When puncture wounds or scars are numerous the branches die and cause the characteristic flagging.

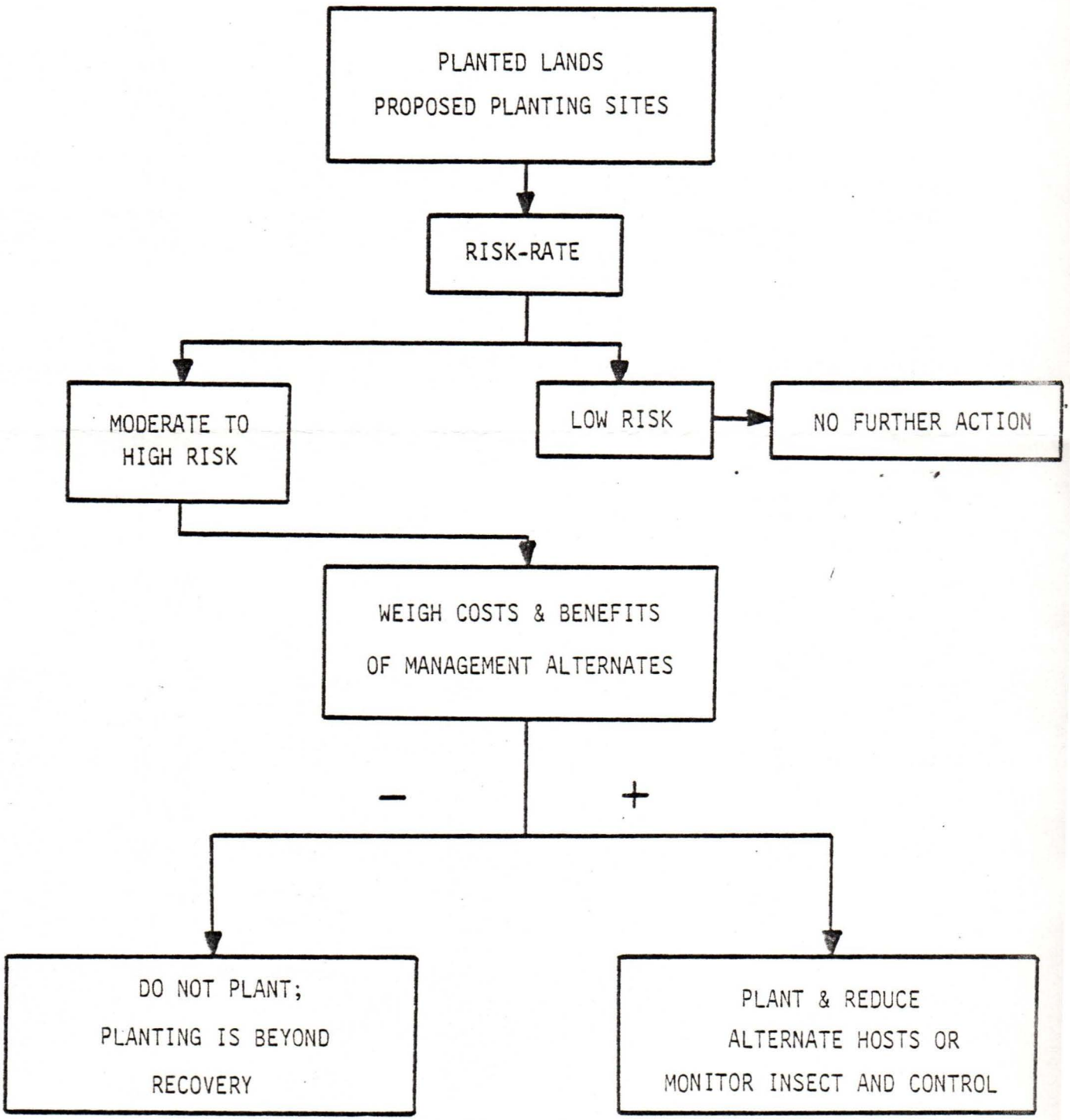
NYMPHAL HOSTS

The Saratoga spittlebug nymph feeds on several woody and herbaceous ground cover plants of the forest floor. Only the adult feeds on pine. Important nymphal hosts are: Sweet-fern, Comptonia peregrina (L.) Coult.; Willow, Salix spp.; Bramble, Rubus spp.; Orange hawkweed, Hieracium aurantiacum L.; Low Blueberry, Vaccinium vacillans Torr.; Sour-top Blueberry, Vaccinium myrtilloides Michx.; Goldenrod, Solidago spp.; Sheep-Sorrel, Rumex Acetosella L.; Old-field Cinquefoil, Pontentilla simplex Michx.; Spotted knapweed, Centaurea maculoa Lam.; Everlasting, Antennaria neglecta Green; Meadow-sweet, Spiraea alba Du Roi; Wild lettuce, Lactuca canadensis L., Prairie ragwort, Sececio plattensis Nutt.

Sweet-fern, which heads the list, is the most important host. Heavy infestations are often related to the amount of sweet-fern in a plantation. Nonhost plants are grasses, sedges, lichens, mosses, and club-mosses.

APPROACHING THE PROBLEM

The following flowchart presents the steps involved in assessing the influence of the Saratoga spittlebug on the management of proposed red pine planting sites or established plantations.



RISK-RATING

Prospective red pine sites should be risk-rated for potential spittlebug injury before planting. Established plantations, too, can be risk-rated. There are three risk categories -- low, moderate, and high. Low risk means that injury from spittlebugs will not occur or at most will be negligible. Moderate risk indicates that spittlebugs potentially can cause some growth loss, light flagging injury on scattered branch tips, and a few trees can develop crooked stems. High risk indicates potentially heavy growth loss, many crooked stems, and numerous top-killed or dead trees.

Saratoga spittlebugs cause economic damage only when suitable alternate hosts are abundant. Thus, we consider the kinds and density of alternate hosts when selecting planting sites or when determining the risk of injury to young red pine stands. Of the numerous alternate hosts sweet-fern is the most important because heavy spittlebug infestations are usually correlated with the density of sweet-fern. A prospective planting site or plantation is risk-rated by estimating the amount of sweet-fern relative to the amounts of other ground cover plants.

Risk-rating should be conducted between May and September so that alternate hosts can be easily identified. However, the procedure should be done by mid-June in young plantings in the event control measures are needed that year.

Well-stocked stands of red pine more than 15 feet tall and not yet showing visible spittlebug injury symptoms are safe and need not be risk-rated. Trees over 20 feet tall are usually safe at any stocking density.

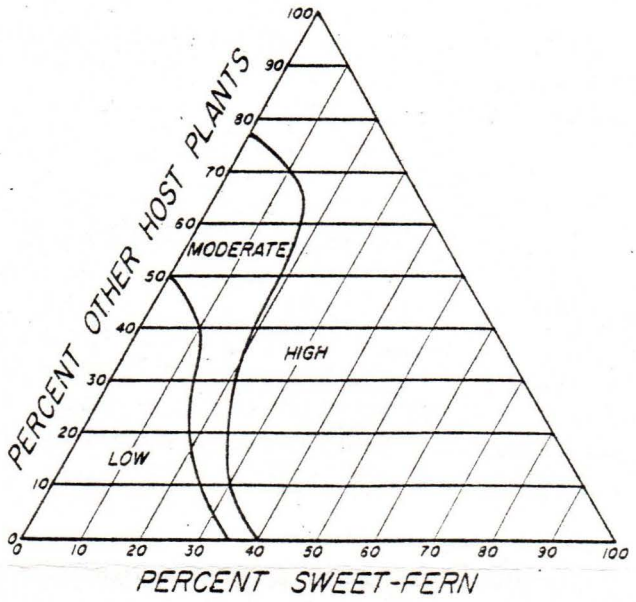
The equipment needed for a ground survey includes: a large scale sketch or map of the planting, a clipboard and pencil, and a risk-rating form.

GROUND SURVEY

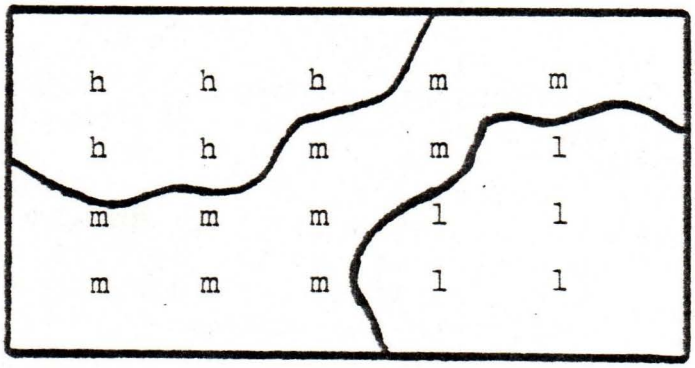
1. Draw transect lines on planting sketch or map. Make transects parallel and spaced 2-5 chains apart. In unplanted land with good visibility use a 5-chain spacing and as lateral view is inhibited by trees and/or terrain, use a spacing as close as 2 chains.

2. Walk transects. Stop every 2 chains to observe the ground cover. First, estimate percent of ground cover occupied by sweet-fern, and then the percent occupied by nonhosts. (i.e., grasses, sedges, liches, mosses) and bare ground. Then estimate percent of the other host plants or determine them by subtracting the percent sweet-fern and percent non-hosts from 100 percent.

3. Use risk-rating triangle to determine if risk is low, moderate, or high at each stop. Place a small l, m, or h at each stop to indicate low, moderate or high risk, respectively. NOTE: While walking transects, observe and note any changes in overall ground cover. This will help you draw boundaries between areas of different risk.



4. After completing all observations, draw boundaries on the sketch or map of area, enclosing areas of similar risk.



5. Determine the acreage in each risk category.

6. See section on Management Strategies to formulate plan of action, if moderate or high-risk areas are present.

At times, it will be difficult to distinguish low from moderate risk and moderate from high risk. When this occurs, there are two rules of thumb:

1. If this is unplanted land or if trees are shorter than 8 feet tall favor the greater risk. Otherwise favor the lesser risk.

2. If bare ground, moss and/or lichens comprise greater than 25 percent of the ground cover canopy, favor the lesser risk.

HELICOPTER SURVEY

A helicopter survey is useful for risk-rating a large number of established plantations or proposed planting areas. Low risk areas can be distinguished from moderate and high-risk areas, and an excellent perspective of the size and distribution of different risk areas within each plantation is possible.

HOW TO SELECT A MANAGEMENT STRATEGY

After risk-rating an unplanted areas or plantation, one decides whether further examination is needed. If the risk is low, the potential damage is also low and further evaluation is unnecessary. If risk is moderate or high, however, further evaluations, decisions, and actions are warranted.

UNPLANTED SITES

On unplanted land risk-rated moderate or high, one has the option to (1) plant and accept the risk, (2) plant and monitor the insect and control any threatening populations, (3) reduce the alternate hosts for long-term control of the spittlebug and then plant, or (4) not plant. A selected strategy should be economically sound. The costs of each strategy should be carefully weighed against the benefits, and a strategy providing an acceptable return on investments should then be selected.

More specifically, the present value of returns (PVR) is compared to the present value of costs (PVC) to derive the net present value (NPV) of a particular management strategy (NPV=PVR-PVC). This is done by discounting projected costs and returns at the desired rate over the period in which each cost or return is to be realized. If the resulting net present value is greater than

or equal to zero, (PVR $\geq$ PVC) the management strategy in question produces or exceeds the desired return on dollars invested. In addition, the size of the positive net present value indicates additional dollars which can be spent now and still achieve the given return. A negative net present value means the management strategy does not provide the desired return on investment. Again, the size of the net present value represents the dollar amount in present money (money which can be spent now) which a project either falls short (-NPV) or exceeds (+NPV) the desired return on investment.

Here is an example using net present value to select the best management strategy. Let's assume we want to plant an area to red pine, and this acreage has significant portions in the moderate and high Saratoga spittlebug risk categories. We want to plant 600 trees per acre to be harvested at age 45 as pulpwood. For the purpose of this example, we set establishment cost at $116.72 per acre (the cost of hand planting)1/. Any additional costs and the returns expected will depend on the management strategy selected. Table 1 presents the net present values resulting from diferent management strategies for site indexes 50, 60, and 70. The yields were calculated using a computer model of red pine yield2/. The yield in cords of each management strategy was used to determine stumpage prices.3/

The upper and lower limits of growth loss in a moderate-risk areas are 4 and 10 years, respectively. Growth loss caused by the Saratoga spittlebug more or less uniformly affects the productivity of the entire tree, so one sees a reduction in height and diameter growth. Thus, reduced yields from growth loss were calculated by using the volume yields of a rotation shortened by the years of lost growth. For example, given 4 years growth loss, the yield of this planting would be calculated for age 41 years instead of 45 years. Stumpage price was not changed to reflect difference in handling, loading, and hauling costs resulting from increased limbiness, crook or sweep.

1/ Cost of handplanting = $43.82 + (41.298 + .051 x trees/acre) taken from Olson, et. al. 1978).

2/ Red pine yield computer model developed by A. L. Lundgren, principal economist, USDA, Forest Service, St. Paul, Minnesota

3/ Stumpage price/acre = 6.44 + (.36 x cords harvested) - Equation developed by Jeffrey T. Olson, economist, Michigan Department of Natural Resources.

Examining Table 1, it is apparent that accepting the risk of injury is not an option for high risk areas or for moderate risk areas of site index 50 or less at the selected rates.

Table 1. Net present values per acre for different management strategies and site indexes for moderate and high Saratoga spittlebug risk planting sites. The proposed planting is 600 red pine per acre to be harvested at age 45.

Strategy	Moderate Risk				High Risk			
	Site Index 70							
	Net Present Values at rate (%)				Net Present Values at rate (%)			
	7	8	9	10	7	8	9	10
Accept Risk (lower limit)[1/]	246	122	41	-12	--	--	--	--
Accept Risk (upper limit)[2/]	216	83	3	-44	-117	-117	-117	-117
Reduce Alternate Hosts[3/]	265	114	15	-49	265	114	15	- 49
Monitor & Spray[4/]	314	164	66	1	307	157	59	- 5
No Risk[5/]	325	174	75	11	325	174	75	11
	Site Index 60							
Accept Risk (lower limit)	89	19	-27	-58	--	--	--	--
Accept Risk *upper limit)	81	2	-45	-73	-117	-117	-117	-117
Reduce Alternate Hosts	132	27	-42	-88	178	57	- 23	- 74
Monitor & Spray	136	46	-12	-50	128	39	- 19	- 57
No Risk	146	56	- 2	-41	146	56	- 2	- 41
	Site Index 50							
Accept Risk (lower limit)	-10	-47	- 70	- 86	--	--	--	--
Accept Risk (upper limit)	- 6	-50	- 77	- 92	-117	-117	-117	-117
Reduce Alternate Hosts	1	-60	-100	-126	32	- 39	- 86	-117
Monitor & Spray	14	-35	- 67	- 88	7	- 42	- 73	- 93
No Risk	31	-19	- 52	- 74	31	- 19	- 53	- 74

1/ Moderate risk = 4 years lost growth.

2/ Moderate risk = 10 years lost growth. However, yield at 45 years was discounted to age 55 because loss of 10 years growth at age 45 reduced yield below acceptable limits. High risk = total loss.

3/ Cost = $60/acre. Reducing alternate hosts increased site index by 5 for moderate risk areas and 10 for high risk areas for site indexes 50 and 60. No data for yields on site indexes greater than 70 was available.

4/ Spray cost = $12/acre for aerial application. Moderate risk areas were evaluated three times and sprayed once. High risk areas - 3 evaluations and 2 sprays. If site index is less than or equal to 50 - add 1 evaluation and 1 spray to account for increased length of spittlebug susceptible height stage (3 to 15 feet) due to slow growth.

5/ Yield expected with no threat of loss or need to control presented for comparison.

Monitoring and spraying consistently produces the highest return. Reducing alternate hosts is a much more expensive operation, yet it provides greater NPV's than accepting the risk in most instances. The only exceptions to this are for discount rates of 8 to 9 percent in moderate risk-lower limits on site index 70. However, any increase in productivity of the site from reducing ground cover competition was not considered because of a lack of yield data for site indexes greater than 70. The net present values for site indexes 50 and 60 do include an increase in yield reflecting a release from ground cover competition. This is shown most dramatically in the high risk areas with site indexes of 50 and 60. Here, reducing alternate hosts yields higher NPV's than monitoring and spraying.

Reducing alternate hosts provides protection for future crops! Thus, monitoring and spraying may produce higher returns for the present rotation. Future plantings, however, can still derive benefits from the reduction of alternate hosts.

PLANTATIONS

Basically, the same procedure for making management decisions for proposed planting sites is used in established plantations. The present value of returns is calculated by discounting the value of the crop at maturity by the number of years to maturity at the desired interest rate. The present value of returns (PVR) is then compared to the present value of costs (PVC) for each management strategy (and any other costs to be incurred) to calculate net present value (NPV). If the trees are already injured (i.e., growth loss, deformity or mortality) the value of the crop at maturity is modified by then accounting for reduced yield from growth loss and/or tree mortality and/or deformities which may alter the value of the crop.

If monitoring and control is chosen as the best management strategy, a nymphal survey (referred to as monitoring) is scheduled for the 3rd year of the plantation. In older plantations, the survey should be made that year. Control of the adult spittlebug is then recommended on the basis of this survey.

SARATOGA SPITTLEBUG MANAGEMENT

The Saratoga spittlebug can be managed by preventive, cultural, and chemical measures. Prevention involves restricting the planting of spittlebug susceptible pines to only the no-risk or low-risk areas. This may mean not planting an entire area or omitting just a few small islands or pockets where the important alternate hosts predominate. Not planting a small portion of an area may greatly enhance aesthetic and/or wildlife values in some regions.

Pockets with 35 percent or more of the ground cover in sweet-fern are especially troublesome, and if planted and then infested, there is a near certain probability of high injury without control. Even if high spittlebug injury does not occur, such areas usually produce slow growing trees until after crown closure from direct competition with sweet-fern.

Cultural control implies reduction of the principal alternate hosts, especially sweet-fern. Deep plowing disrupts and buries sweet-fern and usually curtails rapid regeneration. However, this disrupts soil structure and water-holding capacity of the plowed soil layer. This may be critical in sandy soils. Shallow plowing or mowing stimulates growth of sweet-fern and should be avoided unless repeated for 2 to 3 years, the cost of which may be prohibitive. Chemical herbicides do not disturb the soil and provide what appears to be the most reasonable method of reducing ground vegetation. Herbicides suppress sweet-fern, brambles, and certain other alternate hosts when applied properly and seem to provide long term suppression which will benefit future crops.

Registered pesticides may be used effectively against the adult spittlebug. Pesticide application must be timed precisely between adult emergence and egg laying (usually early July). In high-risk areas, 2 or 3 applications may be needed before the trees outgrow the risk. Spray operations are recommended on the basis of the insect evaluation survey, not on damage symptoms. Damage symptoms are a result of the previous year's injury, and spittlebug populations may have since collapsed.

ACKNOWLEDGEMENTS

The authors acknowledge the contributions of the following individuals in the Michigan Cooperative Forest Pest Management Program: Gary A. Simmons, Jeffrey T. Olson, Daniel G. Mosher, Ronald L. Murray, Marcia A. McKeague and Scott T. Wilson.

LITERATURE CITED

Olson, J. T., A. L. Lundgren, and D. W. Rose. 1978. Equations for estimating stand establishment, release and thinning cost in the Lake States. USDA For. Serv., Res. Pap. NC-163. North Cent. For. Exp. Stn., St. Paul, MN.